KC-130 ANVIS/HUD Assessment and Symbology Rationale.

SUMMARY

Naval Air Systems Command (AIR5117D) tasked the Flight Test Engineering Group (FTEG) of the Naval Air Warfare Center Aircraft Division (NAWCAD) to conduct a technical analysis of the "Blue" night vision device (NVD) Lighting Kit as installed on the KC-130 aircraft. As a part of this analysis FTEG was additionally tasked to provide a "quick look" evaluation of a manufacturer installed, ANVIS compatible, Head Up Display (HUD). The HUD was provided through an unsolicited proposal by Elbit Corp. of Isreal. On 15 Dec 1993 a follow up meeting was conducted regarding aircraft installation, concurrently a symbology review occurred. Several subtle symbology and logic changes changes were made based on experience gained while flying other platforms with a similair HUD installed. Those changes recommended during the 15 Dec meeting are *italicized* . The intent of this technical memorandum is to provide a rationale document for future use.

Patuxent River

Maj Lakaszow

25 Feb 94

[redacted]

CLEARED
FOR OPEN PUBLICATION
FEB 25 1994
PUBLIC AFFAIRS OFFICE
NAVAL AIR SYSTEMS COMMAND
AS AMENDED

INTRODUCTION

BACKGROUND

1. On completion of developmental testing and operational analysis of the ANVIS/HUD an Aircrew Systems Advisory Panel (ASAP) met at the Aircrew Systems Evaluation Facility (ASEF) lab at NAWCAD Pax River from 20-21 January 1993. A wide cross section of the "Fleet" was invited and participated in the iterative design process review that led to development of the symbology sets discussed.

The Rapid Prototyping computers in the ASEF allowed immediate feedback of design suggestions provided by the ASAP memoers. Each element of the symbology set was scrutinized. A "what if" analysis was easily carried out. Particular emphasis was placed on the symbology set being intuitive in nature, that is to say that the elements would stand alone and could be understood without spending time analyzing the presentation. Throughout the design stage we constantly referred to the ultimate end user and the fact that they will be trained from the ground up beacuse of the limited NVG/HUD experience in the KC-130 community.

The following display design principles were considered during the display development:

1.Does the pilot's need justify the display ?
2.Have all the necessary data been provided to the pilot ? If not, what additional data are required ?
3.Can the average pilot easily obtain the required data?
4.Does the display conform -
- to the real world ?
- to other cockpit dispalys ?
- with previous pilot habit and skills ?
-with required decisions and actions ? (ref 1.)

PURPOSE

2. This technical memorandum presents information and lessons learned gathered during DT&E and operational assesments of the Aviator's Night Vision Imaging System (ANVIS) ANVIS/HUD in the KC-130. Information gained during technical research is presented and was integrated into the thought processes discussed herein. This information is not all inclusive, ideally this document will serve as a genisis for future DT&E , OT&E and serve as a rationale document.

RESULTS AND DISCUSSION

GENERAL

3. With the experience and information gained from a limited quick look and subsequent operational asssesment, the following will discuss coasideratuions and rationale used to develop the initial symbology sets.

DESCRIPTION OF EQUIPMENT

"THE HUD COLORING BOOK"

4. THE HUD COLORING BOOK, reference 2, a document produced by Capt Robert E. Hughes MC USN (ret) provided recommendations based on his collection of operational experience and research efforts. The ASAP used the Coloring Book as a starting place and a source document when areas of conjecture or disagreement were presented. It is important to note that the HUD Coloring Book addresses HEAD UP DISPLAYS, devices fixed to an aircraft frame that provide flight information.

The Design Handbook for Head Up Displays, reference 3, was made available after the initial ASAP meeting. Both of the references are designed for use by designers of fixed position HUDs as installed in TACAIR aircraft of the past decades. Although the references were designed for fixed position HUDs, some of the observations contained therein are applicable to NVD/HUD design, therefore both references are sometimes quoted and often referred to throughout this technical memeorandum.

The intent of this document is to address the similairites and the multitude of differences when a "HUD" is attached to a Night Vision Device (NVD). Granted they are both called HUDs, however, the differences in mechanization and operational use are significantly different. A follow on assumption would suppose that information on a HUD is information on a HUD. True to a point, specifics such as scan, and the ability to view flight instruments when looking off axis of the aircraft flight path are just two examples of dis-similarities.

NIGHT VISION DEVICES

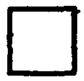
5. The evaluation aircrews utilized the SPH-3C helmet with modifications to allow inflight use of the AN/AVS - 6 , Type 1, Class A, third generation (GEN III) ANVIS throughout the evaluations.

HUD

[redacted]

6. A symbol generator using bit plane memory compiled information from various instruments in the aircraft and created an optical display that was presented on an imaging device which attached to the ANVIS image tube. Appendix A contains a photograph of the imaging device.

The 512 x 512 pixel array display occupied an 8.3mm x 8.3mm area which provided a square field subtending 24° on a side (34° diagonally). Figure (1) is to scale (measuring 8.4 mm x 8.4 mm) and represents the total area provided for the projected images.



REPRESENTATIVE DISPLAY AREA

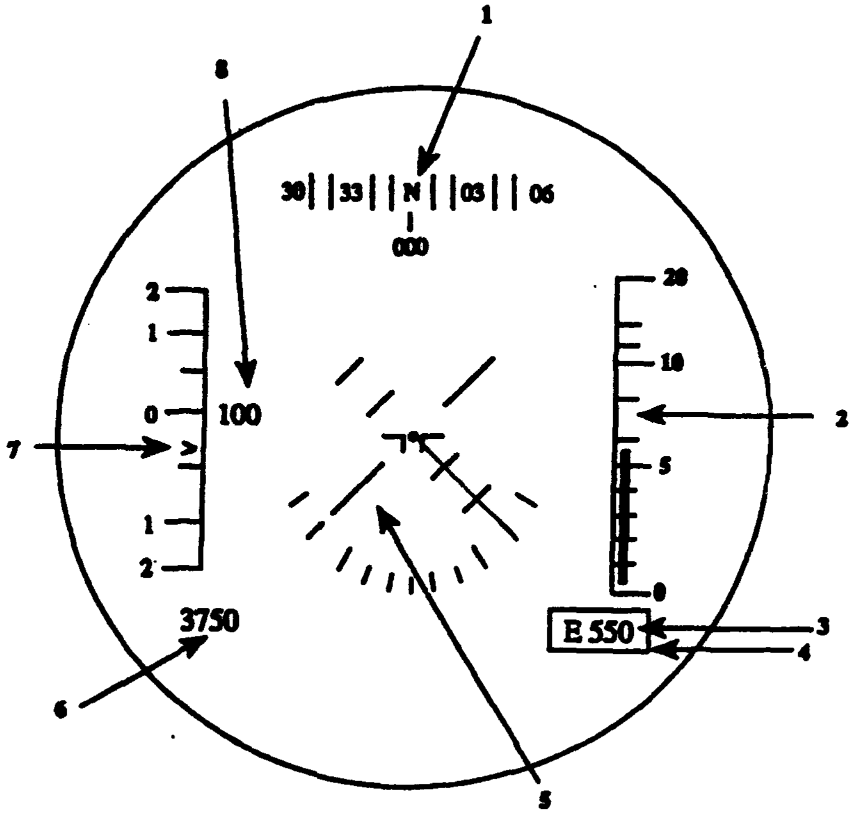
Figure 1

The projected HUD display was superimposed on an 11mm x 11mm square. Horizontal and vertical adjustments of plus or minus 1 mm allowed the operator flexibility in adjusting the display both horizontally and vertically.

INITIAL HUD SYMBOLOGY (FULL MODE)

7. The initial sybology sets produced and provided by Elbit Corp of Israel is presented below . These symbology sets were used during the developmental testing and operational assesment. The flexibility of rapid prototyping allowed the ASAP to take the initial symbology sets and refine them to the symbology sets presented in Appendix B. This preliminary, iterative process was accomplished in just two days.

The manufacturer supplied symbology (full mode) is presented in Figure (2) on the following page . The symbology was utilized during various portions of the "quick look" evaluations.



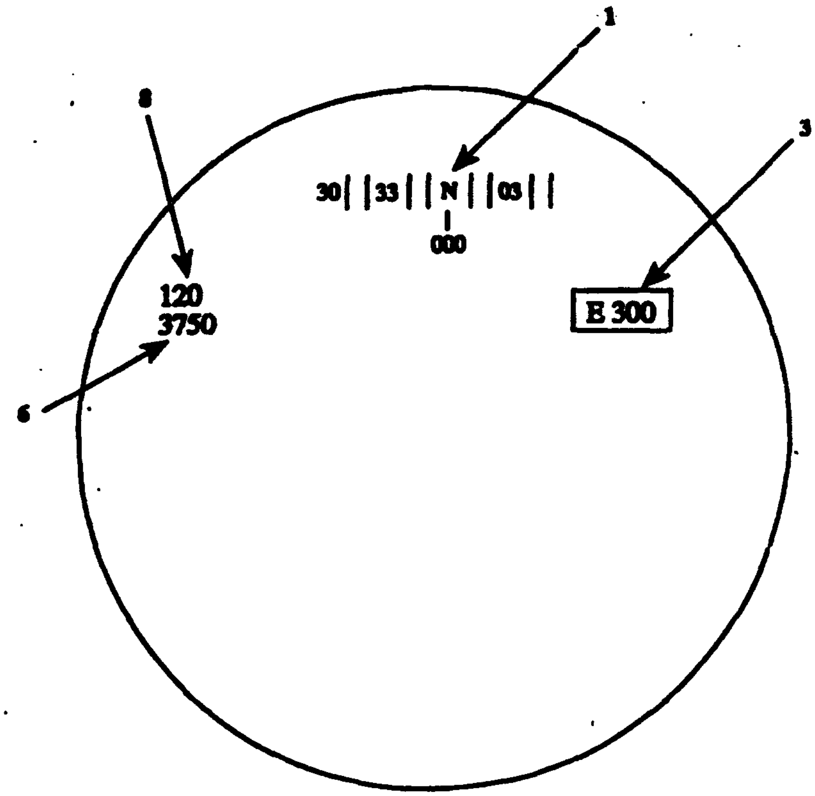
1. HEADING TAPE
2. RADAR ALTIMETER (TAPE)
3. RADAR ALTIMETER (DIGITAL)
4. LOW ALT WARNING (BOX FLASHES)
5. PITCH / ROLL INDICATION
6. BAROMETRIC ALTIMETER
7. VERTICAL VELOCITY TAPE
8. AIRSPEED (KIAS)

INITIAL FULL SYMBOLOGY SET

Figure 2

INITIAL HUD SYMBOLOGY (DECLUTTERED MODE)

8. The initial decluttered symbology set is presented in Figure 3 on the following page.



1. HEADING TAPE 3. RADAR ALTIMETER ALT WARNING (BOX FLASHES)
6.BAROMETRIC ALTIMETER 8.AIRSPEED (KIAS)

INITIAL DECLUTTERED SYMBOLOGY SET

Figure 3

DEVELOPMENTAL TESTING

9. Various, typical night profiles were flown during developmental testing. The profiles included low level flight at 200 ft AGL , touch and go landings and full stop landings to a blacked out runway at McCall Airfield N.C..

The ANVIS/HUD combination had advantages over the use of ANVIS alone including reduced pilot workload when using outside the cockpit flight references as required during NVD flight. The overlay of presented flight data on the external visual scene allowed more precise control of the aircarft especially during critical phases of flight such as takeoff and landing modes.

PRIMARY FLIGHT REFERENCES (PFRs) CONSIDERATIONS

10. PFRs are displays providing sufficient information for the pilot to fly the airplane during a particular mission segment. "Sufficient information" means that contained in the traditional head-down "basic T", such as airspeed, altitude and attitude. Appropriate substitutions acn be made: α for airspeed, radar altitude for barometric altitude, etc. (ref 2)

PFRs provide data for the pilot to contol the airplane -- climb or descend, turn left or right. Navigation or systems data is not normally included unless critical to the mission segment.

Normally the HUD should be treated as a PFR since the pilot will likely use it as such as if it were the primary flight reference regardless of disclaimers in the flight manual.

As such the NVD/HUD combination should be considered a PFR.

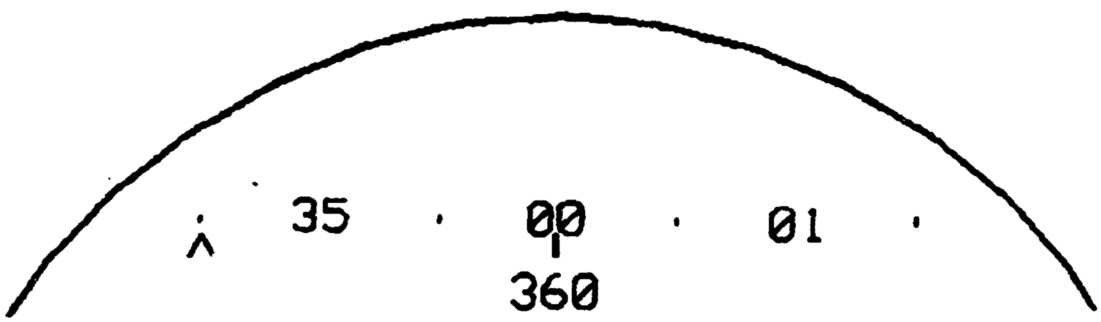
SPECIFIC SYMBOLOGY SETS

11. Four specific symbology sets were developed during the ASAP. Each symbology set has two modes of operation. The normal or clutter mode provides all of the symbology for that given set. The de-clutter mode allows the pilots to use a symbology set with certain predesignated information deselected or de-cluttered. The ability to select different symbology sets and to further de-clutter the symbology allows maximum flexibility of use.

The following paragraphs will discuss specific symbology and attempt to re-iterate the "why" of its development.

HEADING REFERENCE / WAYPOINT MANAGEMENT

12. A horizontal heading scale is centered in the upper portion of the dislay area as depicted in Figure (4).



HORIZONTAL HEADING SCALE & WAYPOINT CARET

Figure 4

[redacted]

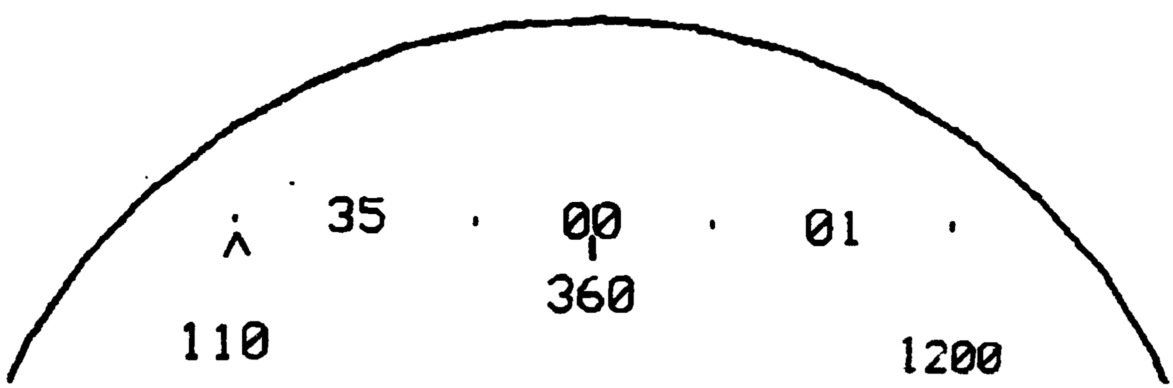
As discussed in the HUD Coloring Book (ref 3) the ASAP attempted to:

- reduce clutter
- minimize the "pseudo-horizon' effect of a long linear scale
- provide plenty of lead information for hard maneuvering to a new heading
- a heading command symbol or caret (<, >, v, ∧) was provided for waypoint management
- the caret symbol was selected instead of a triangle shape in an effort to stem confusion, regarding orientation of the triangle
- the crowded heading tape made shooting self contained approaches difficult, the small amount of movement presented in the heading tape made rolling out on heading difficult and caused additional crew coordination difficulties
- the crowded heading tape also "blurred" during simulated hard maneuvering, both in the aircraft and during computer simulation.

The heading command symbol (caret) provides waypoint management through a set logic process. If the next waypoint is within 65 ° to the left or right of the present heading the caret (∧) is oriented upright. If the next waypoint is 66° to 135° left or right of present heading the caret is oriented horizontally (<) for a heading to the left or (>) for a heading to the right. A heading greater than 135° left or right of present heading results in the caret having an inverted presentation (v). A digital numerical heading readout that displays aircraft heading was provided to minimize heading errors during low level navigation.

AIRSPEED

13. Airspeed is displayed as a digital value in the upper left portion of the field of view as depicted in figure (5).



AIRSPEED

Figure 5

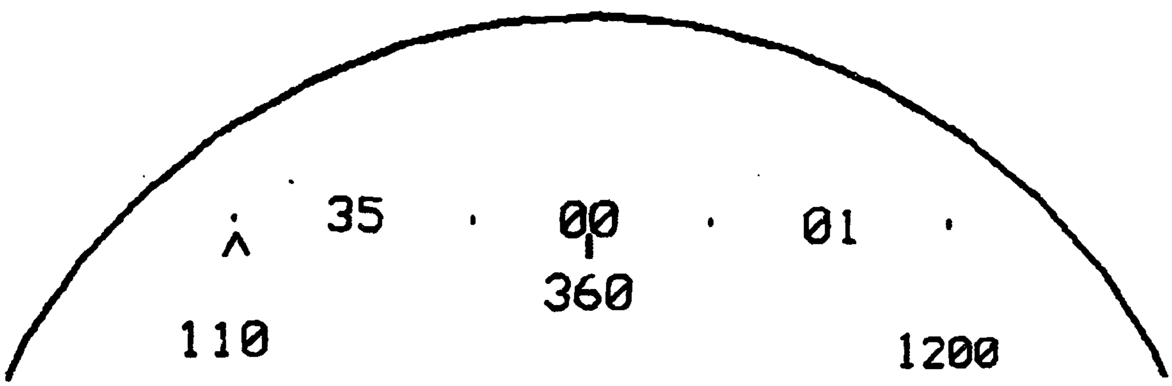
The following considerations were included during the design process:

- the digital value was not boxed
- leading zeroes are not displayed

• circular counter-pointers were not utilized, airspeed range is 0-315 KIAS, accel/decel not so fast as to blur digits alone, the inherent speed stability of the KC-130 allows for selection and maintenance of a desired speed without chasing the value, last but not least the stand alone digits reduce clutter, minimize eye scan and the digits are intuitive
• placement of the airspeed on the left side of the display mimics the airspeed placement in the cockpit

BAROMETRIC ALTITUDE

14. Barometric altitude is displayed as a digital value in the upper right portion of the field of view as depicted in figure (6).



BAROMETRIC ALLTITUDE

Figure 6

The following considerations were included during the design process:

• the digital value was not boxed
• leading zeroes are not displayed
• the "thousands", and "tens-of-thousands" digits are are written larger than the hundreds, tens or single digits
• the disparate sized numbers are aligned along the bottom edge of the larger leading digit
• the single unit column remains at zero giving accuracy to the nearest 10 feet
• circular counter-pointers were not utilized, the stand alone digits reduce clutter, minimize eye scan and the digits are intuitive
• placement of the barometric altitude on the right side of the display mimics the altimeter placement in the cockpit

DEFENSIVE ELECTRONIC COUNTERMEASURES (DECM)

[redacted]

15. The DECM suite in the KC-130 consists of several different devices. The primary threat diplay made available to the aircrew is provided by the AAR-47, an aural warning is provided simultaneously with a visual warning as depicted in Figure (7).

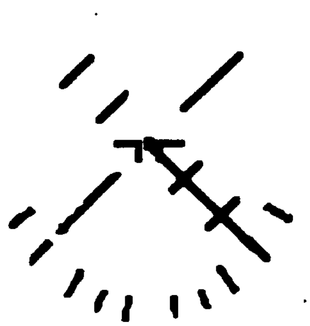
PRIMARY THREAT DISPLAY
(initial and evolved 15 Dec)

Figure 7

• because of the critcality of the information it occupies prime real estate (centered above the pith ladder area)
• the warning duplicates AAR-47 control panel warnings
• displayed only when a threat is actually detected
• indicates quadrant of threat
• *the symbology was altered to display only a large "M" and have an open caret instead of a triangle*

PITCH LADDERS

16. The original pitch ladder shown with the horizon line in figure (8) had several disadvantages.



ORIGINAL PITCH LADDER

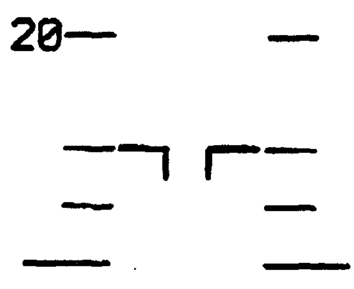
Figure 8

INITIAL PITCH LADDER

• front and center of the field of view was "clobbered", you literally needed to look around the collection of pitch lines that displayed ± 30°

• the solid vertical line displayed through the center of the pitch ladder used prime real estate both in terms of viewing as well as negating the ability to later add flight path velocity vector symbology
• the closely spaced pitch ladder did not offer space to accurately detect small pitching moments of the aircraft
• during the landing flare of short field landings the preferred touchdown zone was occluded by the centered pitch ladder
• the closely spaced pitch lines did not provide adequate pitch configuration cues, especially on short final when transitioning from 50 to 100% flap settings

The evolved pitch ladder is displayed in Figure 9.



EVOLVED PITCH LADDER

Figure 9

EVOLVED PITCH LADDER

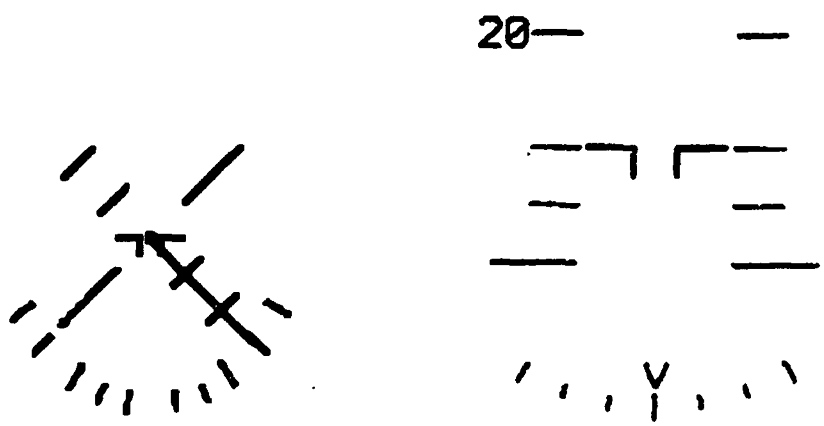
• the maximum amount of pitch information provided at one time is 30° total
• pitch lines above the horizon are solid
• pitch lines below the horizon are dashed
• the first ±10° of the pitch ladder lines are presented in 5° increments
• remaining pich ladder presentations > 10° are in ten degree increments, these increments are identified digitally just to the left of the pitch ladder lines

A five degree increment about level flight was chosen for several reasons:
• ±30° of pitch in the KC-130 is an extremus situation and provided useless information for typical flight regimes
• ±15° of presentation removes clutter and extraneous information

• the initial ten degree spacing did not afford a representative presentation of aircraft attitude change during flap movement. This disparity was particularly evident when transitioning to 100% flaps on short final.
• the additional spacing afforded with ± 5° of level should allow for more precise attitude control during slower phases of flight such as helicopter aerial refueling, aerial delivery configurations and transitioning to and from final landing configuration
• the additional spacing will allow for a 1 to 1 presentation of aircraft pitch that should be detectable

ANGLE OF BANK INDICATOR (BANK SCALE)

17. A bank angle scale is placed immediately below the pitch ladder as shown in Figure (10).



PITCH LADDER WITH ANGLE OF BANK INDICATOR
(initial and evolved)

Figure 10

• The initial angle of bank indicator was presented as a solid line originating at the center of the aircraft symbol and rotated left or right in a pendulum fashion along the circullar angle of bank indicators located on the bottom of the display. This presentation utilized a large prime area of the display and was somewhat distracting.
• The evolved angle of bank indicator drops on an apparent vertical perpendicular from the center of the display , utilizing a caret (v) and mimics the presentation of the aircraft attitude gyro. Aircraft angle of bank is displayed ± 30°, increments of scale are the same as presented on the aircraft attitude gyro i.e. 10°, 20°, 30°,45°, and 60°. The roll angle pointer (caret v) was chosen because a small single line, solid or dashed, was easily lost in the clutter of ground information viewed through the NVDs.

BETA (SIDESLIP) INDICATOR

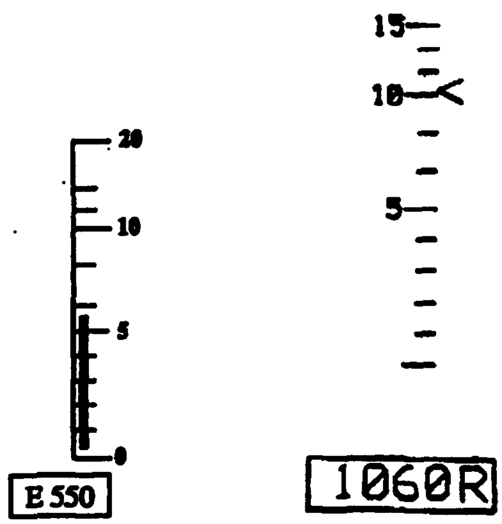
18. The intent of this symbol is to provide "ball" information available in a standard turn needle and ball display found in aircraft. Beta information was not provided during initial flight test. As simple as the concept of a "ball" may seem the ability to electronically obtain the information and acccurately reproduce it is no small engineering accoLaplishment. Figure (11) represents the suggested display format. Dicussion points included:

Figure 11

- use the minimum acceptable presentation in an effort to reduce clutter and occluding the field of view
- poor sideforce characteristics of the KC-130 in the low speed environment and the ability to fin-stall the aircraft make it necessary to have Beta information readily available
- provides information for correct control inputs following an engine loss
- is provided in ALL clutter and de-clutter modes

RADAR ALTIMETER

19. The radar altimeter presentation provided during flight test received considerable attention during the ASAP. Comparing the initial radar altimeter presentation with the evolved presentation in Figure (12) shows subtle changes.



RADAR ALTIMETERS
(initial and evolved)

Figure 12

The radar altimeter display is located to the left of center on the HUD (VVI and torque are to the right). These subtle changes from the initially supplied symbology set attempt to embrace several recommendations provided by Capt Hughes in the HUD Coloring Book. Specifically " Not one "pixel" should be lit unless it "buys its way onto the screen by providing a demonstratable improvement in performance ". Since the concept is primarily Visual Meteorlogiacl Condition (VMC) aviation while using the the NVD/HUD combination the radar altimeter provides critical information during most phases of flight.

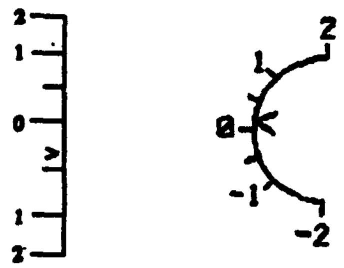
• the vertical scale representing radar altitude height, like the initial scale, is not linear but only provides information from zero to 1500 feet AGL
• a horizontally oriented caret (<) replaces the former solid vertical line and indicates height above ground graphically
• the single vertical line that would connect the horizontal lines on the scale has also been eliminated
• the rad alt digits placed at the bottom of the vertical tape have an "R" immediately to the right to remind the flight crew that radar information is being displayed. The initial symbology (Figure (2)) used the letter "E" representing electronic as a reminder that the numbers were not barometric altimeter information
• the radar altimeter display is available in various selected display modes
• during a climb the rad alt caret moves vertically until 1500 feet, at that point the caret stops and the digital readout continues to 2000 feet
• at altitudes greater than 2000 feet AGL the entire rad alt display is automatically removed
• when descending from altitude the rad alt diplay is envoked at 2000 feet AGL. The digits and associated "R" are displayed at 2000 feet, the vertical tape and associated caret are displayed at 1500 feet. This logic saves space since the majority of flight will be from the surface to 2000 feet AGL. Turning the rad alt display on at 2000 feet AGL gives the aircrew additional time before the vertical tape scale is envoked in cases of excessive rates of descent.
• the digital read-out is accurate to the nearest ten foot increment in an effort to stop continuously moving digits
• when the aircraft is below a pre set minimum altitude as selected on the aircraft radar altimeter a box surrounds the digital altitude readout and flashes
• *activation of the weight on wheels switch (WOWS) after landing removes the flashing box from around the altitude numbers*
• *on takeoff the low altitude box remains OFF until the aircraft climbs through the pre-set altitude and then descends below the pre-set altitude.*

VERTICAL VELOCITY INDICATOR

20. Since the KC-130 is an older generation aircraft using classic pitch and roll attitude reference systems the vertical velocity indicator (VVI) plays an important role in providing "lead" or "trend" information. The trend information is important in the control of altitude, and more importantly helps provide critical information during the final approach segment, flare and touchdown phase of landing. The loss of depth perception and small field of view (40°), while using NVGs provide a perfect environment for "spotting

the deck in close". An accurate VVI provides an additional scan item to help avoid the hard landing trap.

The VVIs (initial and evolved are displayed in Figure (13)



VERTICAL VELOCITY INDICATORS
(initial and evolved)

Figure 13

- the evolved radial presentation more accurately repeats the aircraft VVI as compared to the vertiacl tape presentation in the initial symbology set
- the display is placed to the right and slightly below the pitch ladder presentation in an effort to repeat actual aircraft instrumentation location
- a horizontally oriented caret (<) travels on the inside of the arc indcating the rate of climb or descent
- although the aircraft is capable of vertical rates greater than 2000 FPM normal NVG/HUD operations are expected to be well within the ± 2000 FPM
- it is anticipated that the scaling and radial presentation will offer more trend information than the purely vertical tape format offered
- flaring at night has it's own peculiar difficulties especially in a short field environment at night. With the reduction / lack of depth perception induced with NVD use the VVI will play a critcal role in the landing phase

WAY POINT MANAGEMENT STACK

21. The waypoint mangement stack is located in the bottom right hand side of the field of view and is depicted in Figure (14).

1·5212
215.0
112

WAYPOINT MANAGEMENT STACK

Figure 14

This location was selected so as not to interfere with the ASAPs desire to emulate the aircraft instrument panel with the other symbology and occlude

[redacted]

as little of the field of view as possible. The waypoint management stack presents time (hrs:min:secs) and distance to go to the next or selected waypoint.

GROUNDSPEED

22. Groundspeed is displayed seperately, immediately below the waypoint management stack as depicted in Figure (15).

1·52·12
215.0
112

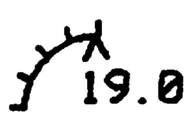
GROUNDSPEED

Figure 15

Groundspeed , like airspeed is displayed to the nearest whole knot. Placing the groundspeed in the lower right corner of the field of view provides an additional safety margin so that in a quick scan groundspeed will not be confused with airspeed located in the upper left hand corner of the field of view.

TORQUE VALUE

23. The primary power indication in the KC-130 is engine torque with a maximum allowable toque value of 19,600 lbs. During flight test no power indication was provided, as a result pilots constanatly broke their inter HUD scan to view the aircraft engine instrument gauges. This scanning procedure literally created a second scan other than inside the NVD/HUD. The torque presentation (located to the right and slightly higher than the pitch ladder) in Figure (16) is radial in design :



TORQUE INDICATOR

Figure 16

- with 0, 5000, 10000, 15000, and 20000 pound increments, not a %
- a caret (<) travels on the inside of the arc indcating pounds of torque
- a digital display of engine torque is provided in decimal format, i.e. 14,700 pounds of torque would be displayed as 14.7
- method of obtaining torque to be dispalyed has yet to be determined, since four seperate sources (engines) are available. Determination as to highest, lowest or average torque has yet to be decided.

CAUTION / WARNING

24. A Master Caution Warning is displayed to the left of the Beta indication as "MST". "SPU" is displayed on the right side of the Beta indication as depicted in Figure (16), "SPU" indicates a power unit failure"MST" is displayed whenever a caution or warning light illuminates in the cockpit.

MST ◻ SPU

CAUTION / WARNING DISPLAY

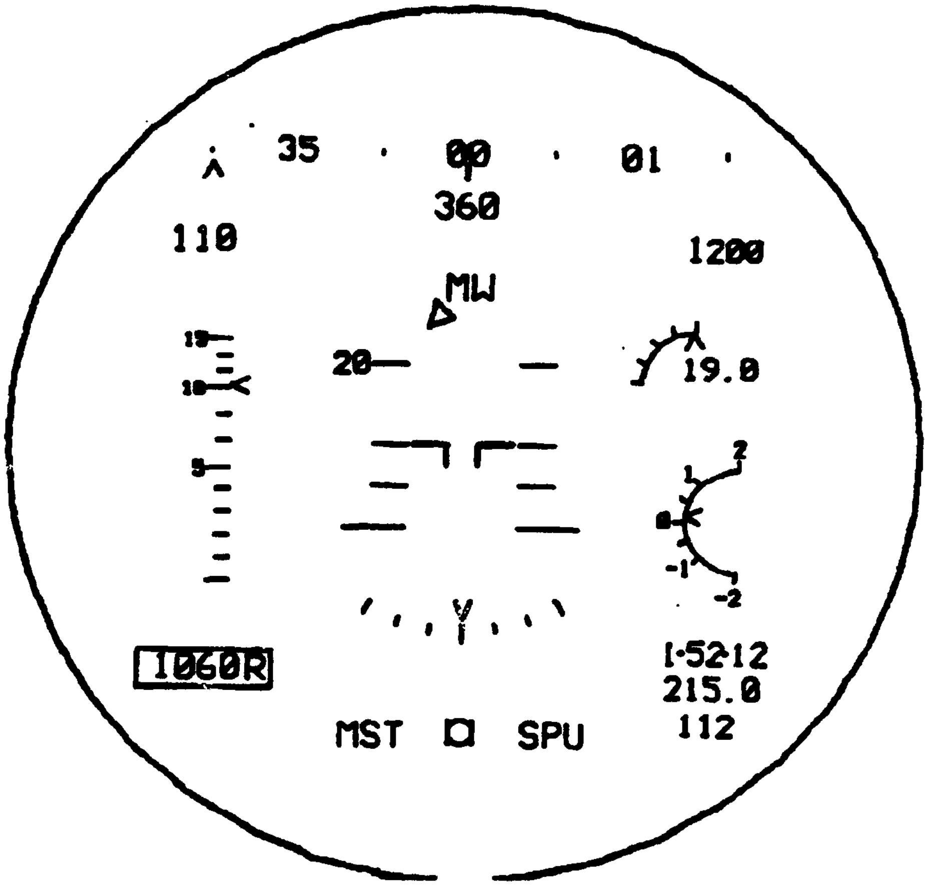
Figure 17

The KC-130 cockpit contains many caution / warning lights that cannot be reset. An example of such a light is a PROP LOW OIL LIGHT, once illuminated and the Emergency Procedure is complied with the light remains on. The only way to note a failure of a second prop is the illumintion of a secondary warning light, ironically many secondary warning lights like primary warning lights cannot be reset .

A future ASAP will be required to determine operational requirements for Caution / Warning displays in the NVD/HUD. The current ASIP 2 & 3 modified aircraft have the Master Caution Warning light, other aircraft do not.

CONCLUSIONS

25. Througho'it the ASAP we used COMMON SENSE and a "WHAT IF " approach. The full symbology set developed during the 20-21 Jan 1993 ASAP meeting is presented in Figure (18)



COMPLETE SYMBOLOGY SET

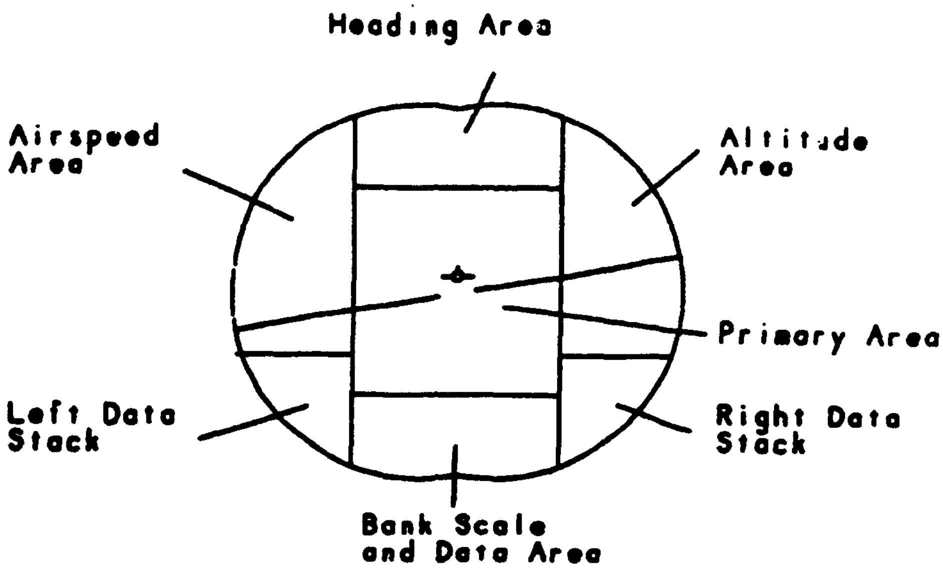
Figure 18

- used the HUD Coloring Book as a reference
- attempted to provide the least cluttered displays possible
- where possible eliminated excess lit pixels
- replicated to the greatest extent possible the aircraft instrument panel
- analyzed the thought process behind other HUD formats
- provided maximum flexibility for future users by formulating a variety of symbology sets
- maximized the ability to formulate options through rapid prototyping in the ASEF

FUNCTIONAL FIELD ASSIGNMENTS

26. Figure 19 , contained in reference 3 labels the generally accepted default locations of functional components, much in the same way that the Basic T concept describes the ideal placement of head-down elements. Even though the HUD information is presented on a 8.3mm X 8.3mm area , eye movement for instrument scan was still required when utilizing the NVG/HUD.

Throughout the design process care was taken so as to not move information toward the display edges with the goal of a resultant decrease in eye scanning movements.



FUNCTIONAL FIELD ASSIGNMENTS

Figure 19

ASAP RESULTS

27. Appendix B represents the first draft results of the January 1993 ASAP. The symbology sets, once prepared and installed by the contractor will require RDT&E and another operational assesment before OT&E and subsequent fleet introduction. The symbology sets are identified as MODE A ... through MODE D each having a full mode and a de-cluttered mode. The ASAP decided not to assign a "name" such as "takeoff mode" to the sets. The ASAP felt that simply naming the mode would connote usage of that mode for that particular mission segment. At this design point there is not enough user data available for prefered use and the ASAP felt that each pilot should have the latitude to choose and use a symbology set as he sees fit.

RECOMMENDATIONS

28. Standardization...... Numerous sources have stressed / offered/ force fed HUD symbology standardaization. The following points should be considered about this NON HUD HUD:

- this HUD is not a fixed position HUD
- this HUD is used only with NVDs
- the primary mission is flight at night in VMC at low altitude (<2000 ft AGL)
- maneuvering is typically ± 10° pitch, ± 1000 FPM, AOB < 60°

[redacted]

• maneuvering rates are much lower than jet type aircraft
• the field of view offered by the NVDs is 40° conically
• the HUD symbology is presented in a format that measures 24° x 24° with a diagnol measurement of 34° when the eye peice is attached to the NVD
• the symbology is viewable off-axis, unlike other helmet mounted displays no head tracking device is used
• older technology is used, i.e. no flight computer, classic attitude reference system
• information must be intuitive and still provide trends
• because of the requirement to obstensively view the world visually (behind or through the symbology) there is simply no room for circular counter-pointer displays
• all " standard symbology "offered has not had mission specific user input
• attempting to lump aircraft or missions together in a standard MilSpec for HUDs serves to only slow or confuse the acquisition process
• the NVD/HUD presentation REQUIRES an eye movement scan just as the entire aircraft instrument panel does.
• proper NVD use, with or without a HUD requires a good instrument scan.

DESIGN PHILOSOPHY

29. The following bullets provide food for thought:

• Standardize to save $$. " The need for absolute standardization in electronic displays is questioned; There " We must not become slaves to standardization for its own sake. Historical symbology ~~standards often reflect the limitations of~~ the symbology generators at the time they were developed and should not be allowed to restrict development of advanced display formats. The primary goal should be enhanced pilot/aircraft performance with HUDs designed and tested with mission performance in mind."(ref 1). Remember the carrier based F-111?

• display specifications and, as a result, MANY display designers in the past have overconcerned themselves with details of the specific symbols. The general arrangement (location within the field of view) and the algorithms driving the symbols are OFTEN more important (in our opinion) than the details if the symbols themselves. (ref 2)

• perhaps the most important recommendation is to have a rational design philosophy when developing head-up displays. The information to be displayed on the HUD must be tailored to the pilot's needs. The choice of specific symbols should be relegated to a secondary role. In the past too much attention has been devoted to micro-standardizing the symbols. The development of the symbol sets must be tailored to the mission, to the aircraft, and to the cockpit environment. Problems in the past have been the result of poor symbology choices, not the lack of standardization. (ref 2)

• as HUDs became widespread, certain de-facto standards have emerged. Some represent the positive results of trial and error, but others are merely expressions of "it's always been done that way". HUD design must be based on the mission needs of the aircraft and pilot and will evolve as technology and missions change. It is important to ensure that any changes from historical

HUDs not be dangerously incompatible with existing pilot techniques and learned habits. (ref 2)

FLEET USERS GROUP

ASAPs that bring together Fleet Users, such as the KC-130 specific meeting on 20-21 Jan 1993 and the generic HUD meeting held on 4-5 May 1993 at Pax River pay numerous dividends. A partial listing follows:

•cross pollination of NVD/HUD users, educating attendees on differing needs of platforms/missions
•reviews lessons learned
•provides a forum for annual updates

ABREVIATIONS

AGL- Above Ground Level
ANVIS- Aviator's Night Vision Imaging System
ASAP- Aircrew Systems Advisory Panel
ASEF- Aircrew Systems Evaluation Facility
DECM- Defensive Electronic Counter Measures
FTEG- Flight Test Engineering Group
FPM- Feet Per Minute
HUD- Head Up Display
MST- Master Caution Advisory
NAWCAD- Naval Air Warfare Center Aircraft Division
NVD- Night Vision Device
NVG- Night Vision Goggle
OT&E- Operational Test and Evaluation
PFR- Primary Flight References
DT&E- Developmental Test and Evaluation
TACAIR- Tactical Air
VMC- Visual Meteoroligical Conditions
VVI- Vertical Velocity Indicator

REFERENCES

1. Loran A. Haworth and Richard L. Newman, Test Techniques for Evaluating Flight Diasplays , NASA Technical Memorandum 103947, February 1993

2. Richard L. Newman, Design handbook for head-up displays, FSWG TR-92-01 December 1992

3. R.E. Hughes, The HUD Coloring Book: Recommendations Concerning Head-Up Displays, Naval Air Systems Command, 1991